

# Environmental Disturbances: Early S5 and S4

LIGO-G060152-00-Z

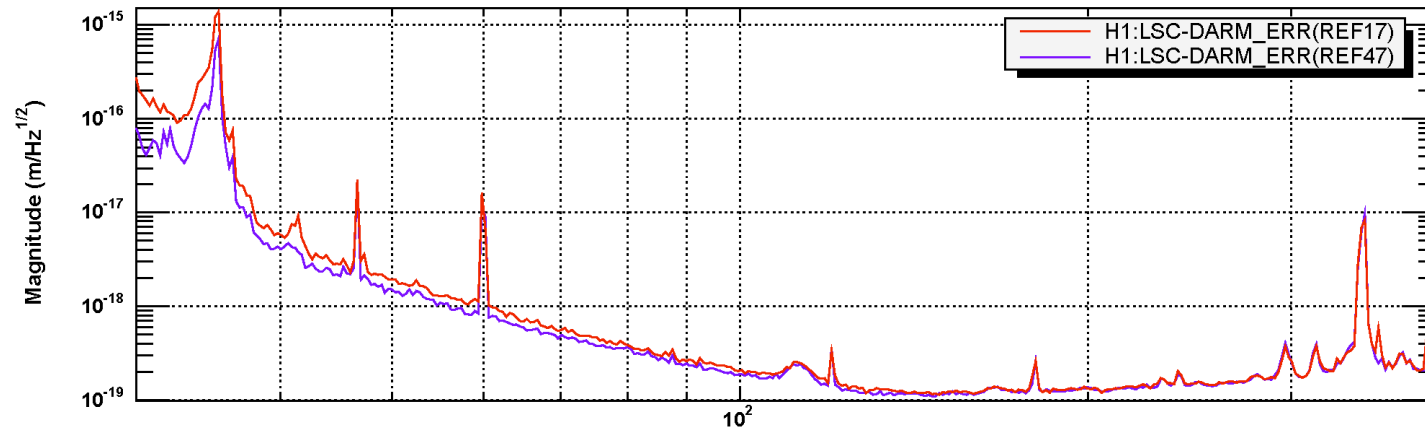
Robert Schofield, U of O

Rana Adhikari, CIT, Richard McCarthy, John Worden, LHO

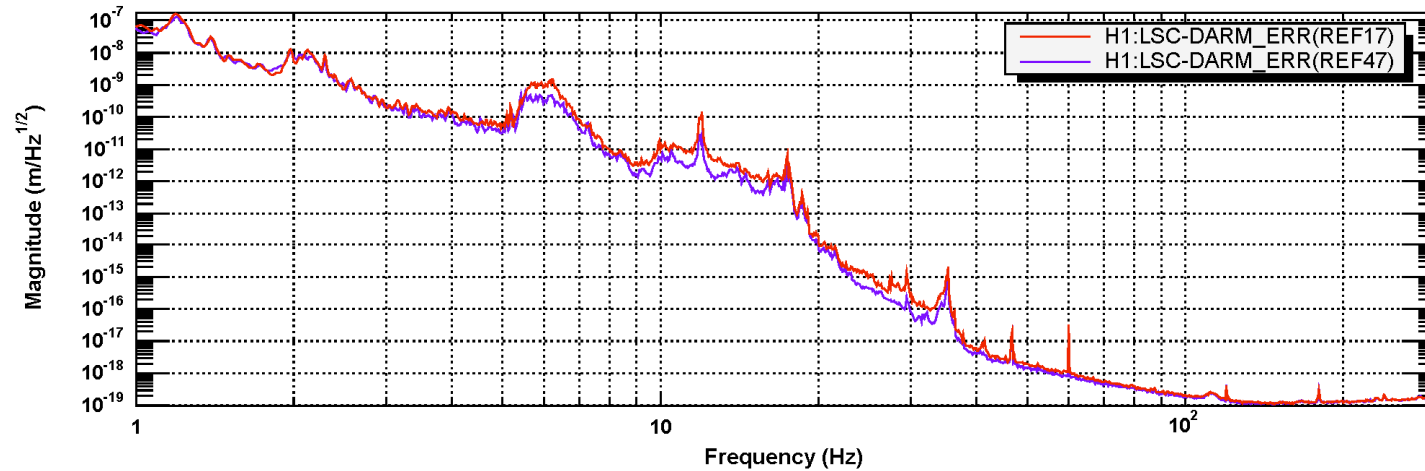
- I. HVAC flow rate reduction improves sensitivity
- II. Seismic up-conversion experiments
- III. S4 H1-H2 coincident events from site activity
- IV. PEM injections
- V. Electronics rack diagnostic magnetometer
- VI. Crab protection

# Gravitational wave sensitivity improves when HVAC off

Power spectrum



Blue: All site turbines and chiller pad equipment off; Red: normal



\*T0=12/02/2006 17:54:39

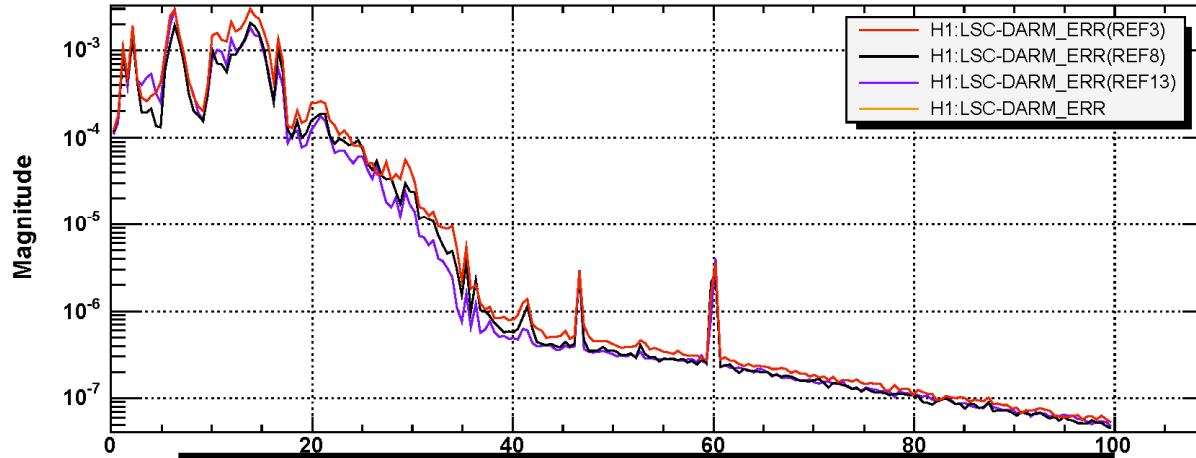
\*Avg=1/Bin=10L

BW=0.0234367

# Half-normal flow rate about as good as fans off

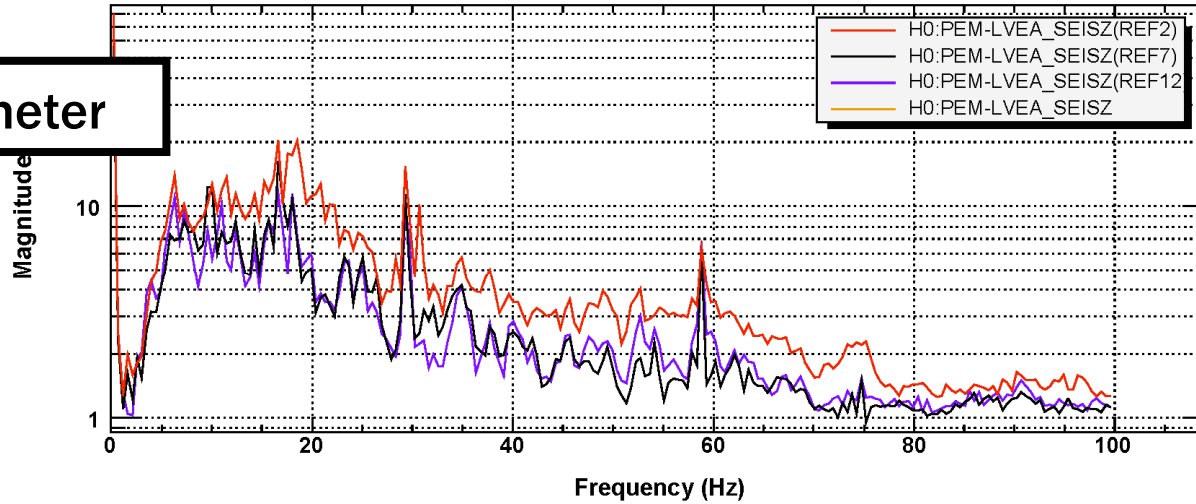
Red: pre-Feb. 15 flow rate, Black: all off, Blue: half flow rate

DARM



Power spectrum Black: off; Blue: 1/2 flow; Red: full flow

seismometer



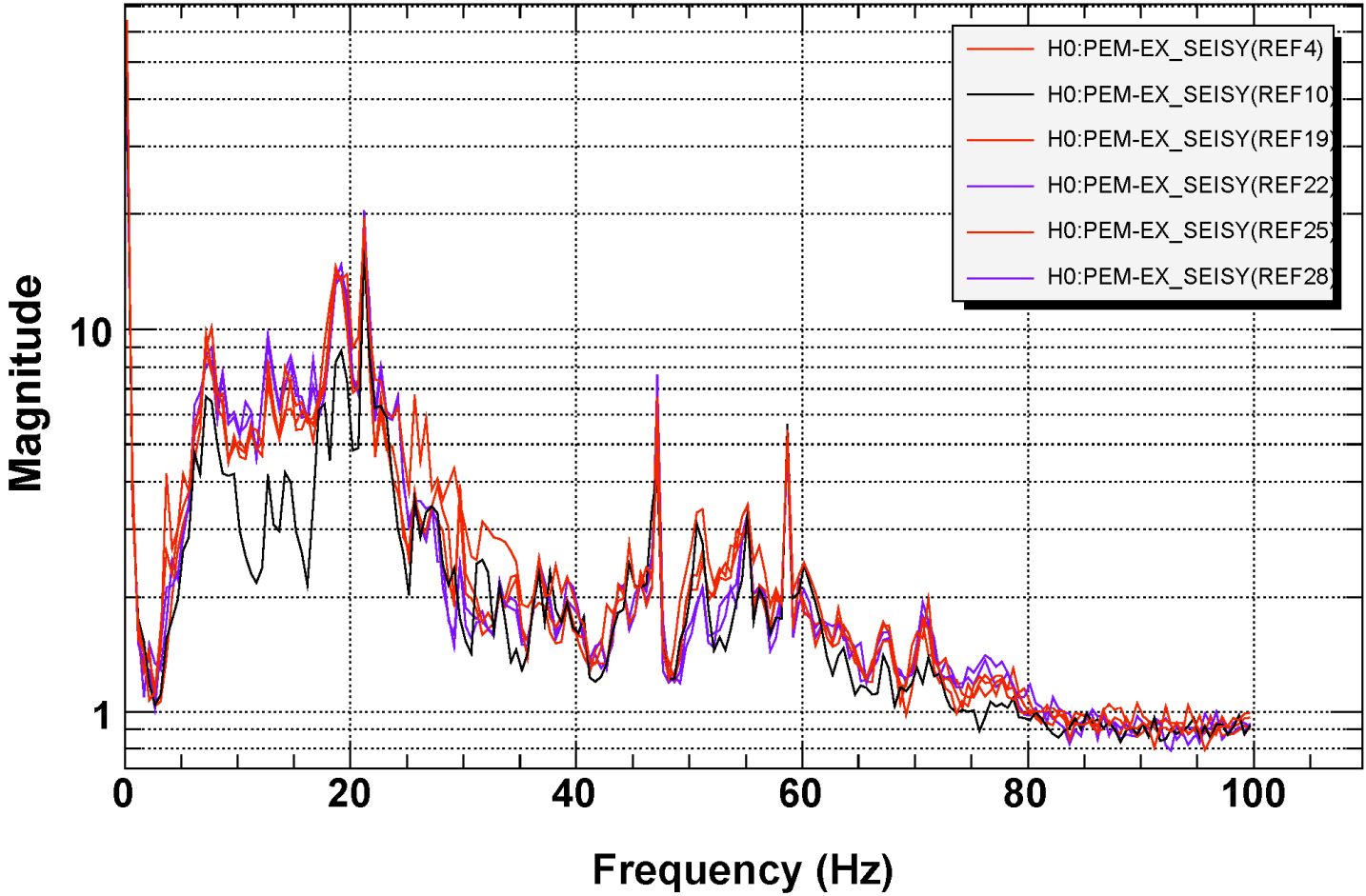
\*T0=15/02/2006 06:35:00

Avg=9/Bin=30

BW=0.0234374

# Seismic noise likely from fan and plenum, not ducts (at X-end)

Black: off; Red: normal flow; Blue: like red but ducts closed off at plenum



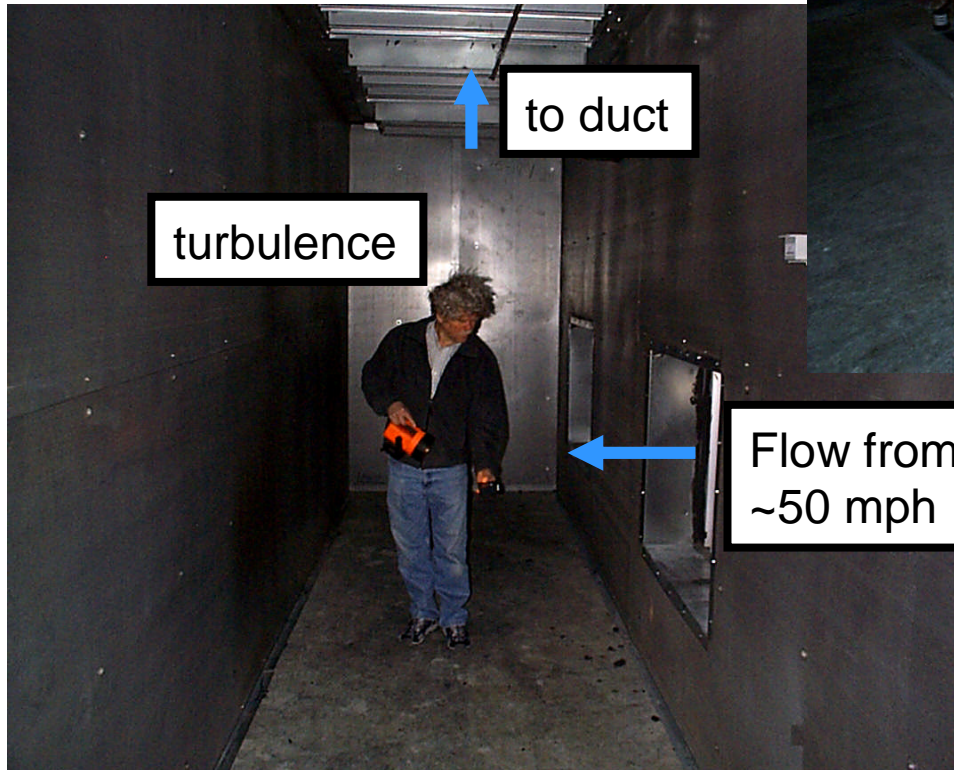
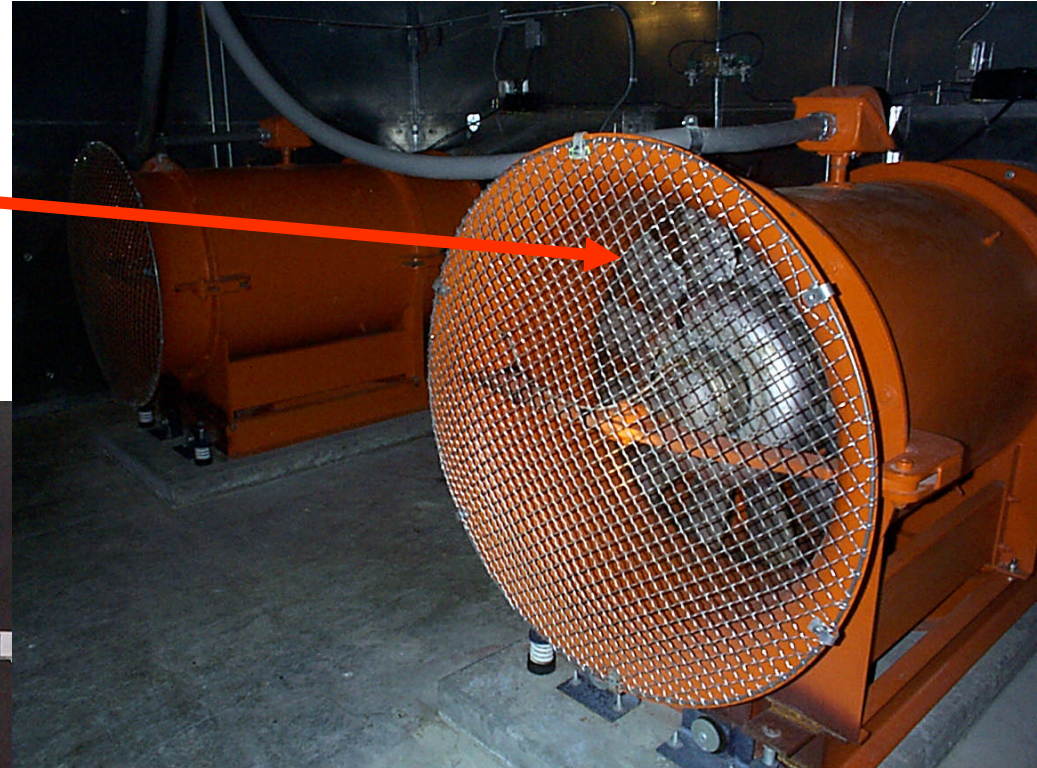
\*T0=17/02/2006 03:07:00

\*Avg=30/Bin=4

BW=0.1875

# Broad-band seismic signal from HVAC possibly produced by plenum turbulence

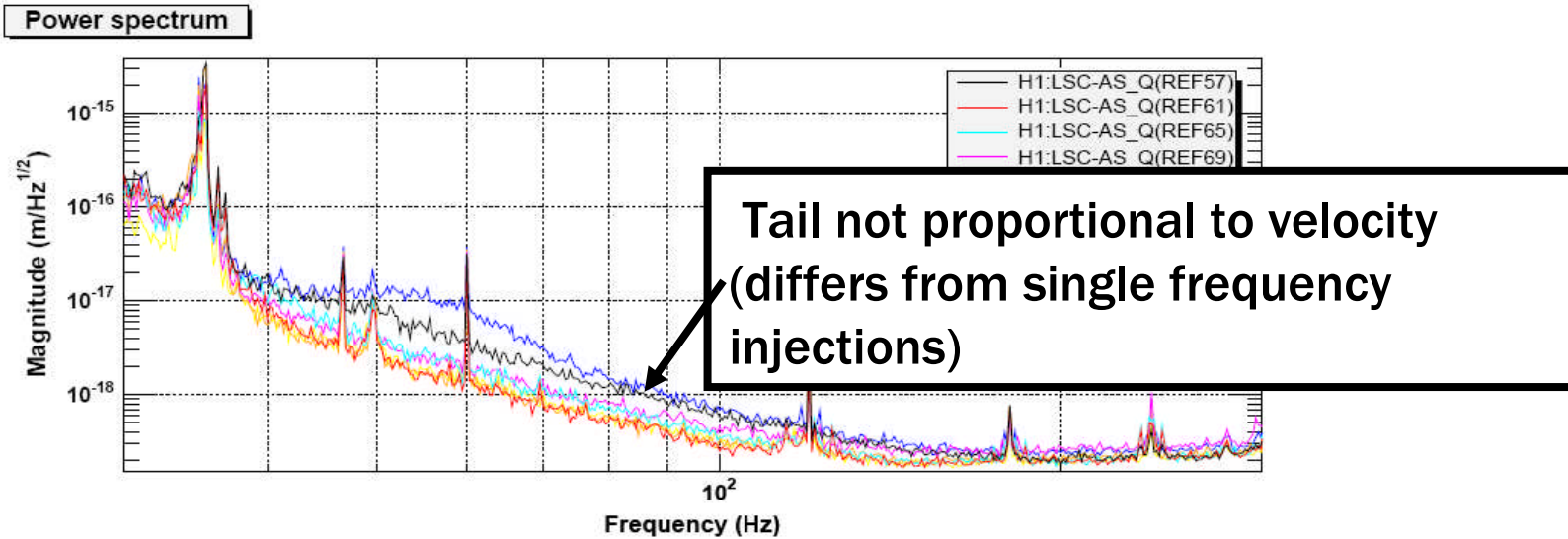
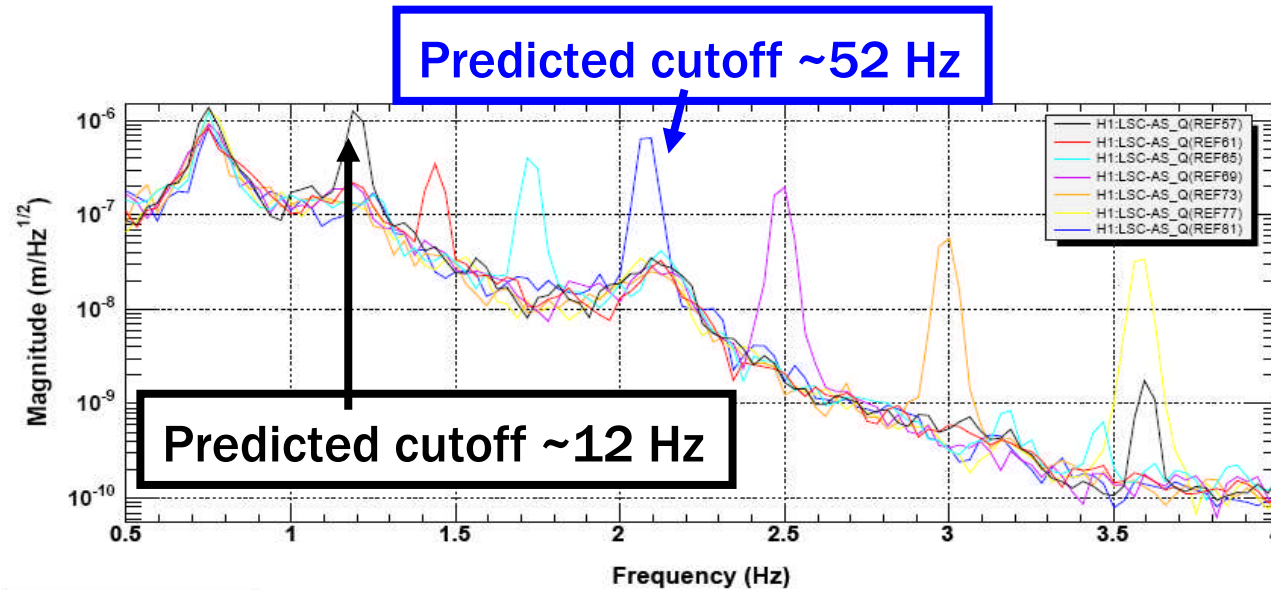
Pitch of blades controls flow rate through turbine



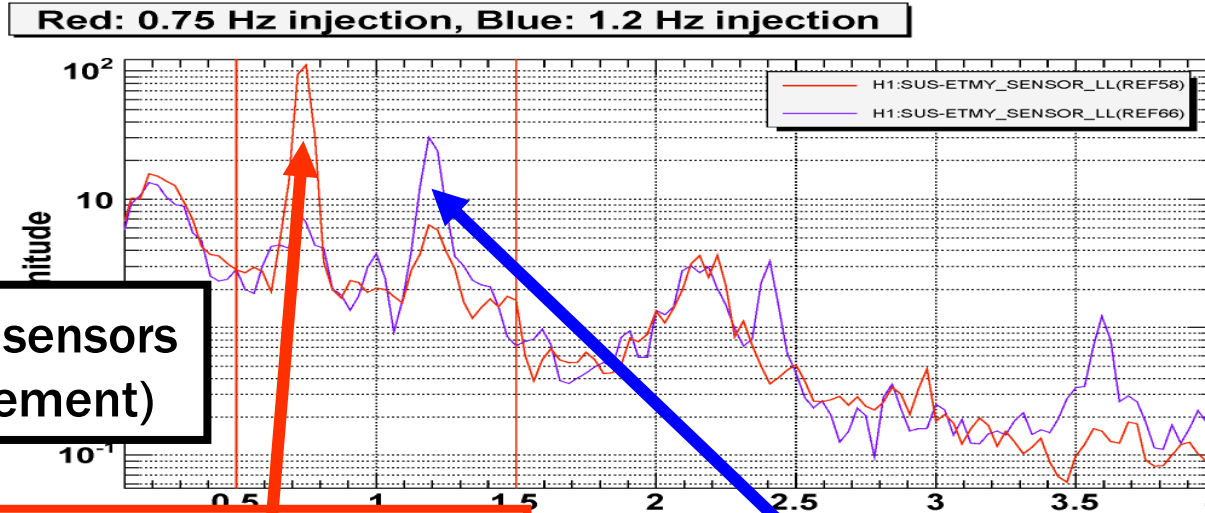
## Summary: HVAC effect on range

- *Shutting HVAC down improves H1 & H2 range about  $\frac{3}{4}$  Mpc.*
- *Influence likely seismic – air flow into LVEA/VEA not needed for range reduction.*
- *Half-flow about as good as HVAC off (seismic level 55% of full flow in 1-50 Hz band).*
- *For  $\frac{3}{4}$  LVEA flow level, seismic rms is only 61% of full flow level. This provides better temperature control and is what we are currently using.*
- *Seismic noise possibly from turbulence in supply plenum.*
- *DARM noise at 100 Hz was likely from up-conversion of lower frequency HVAC seismic signal instead of direct coupling.*

# Simple back-scattering model doesn't explain tail



# Up-conversion **not** from “squeaky” optic suspension point

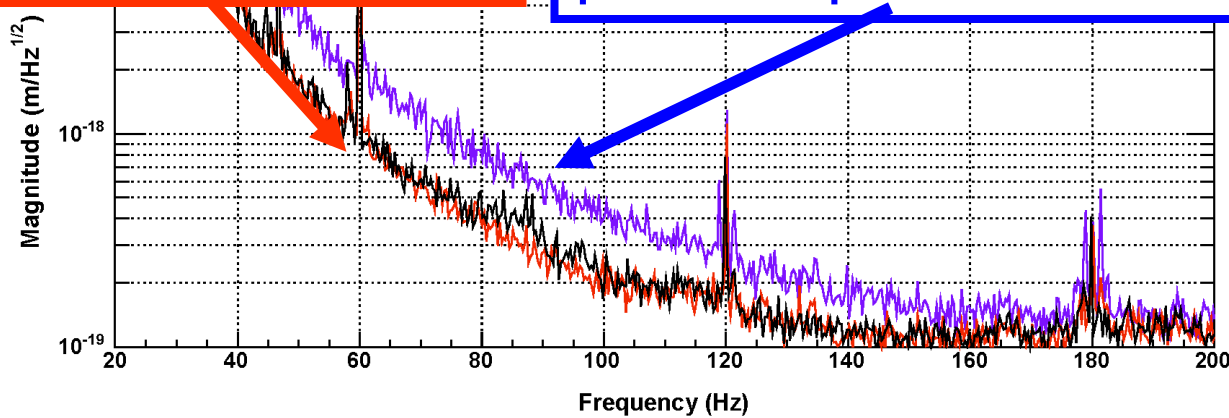


shadow sensors  
(displacement)

large test mass displacement  
produces no upconversion

smaller test mass displacement  
produces up-conversion

DARM



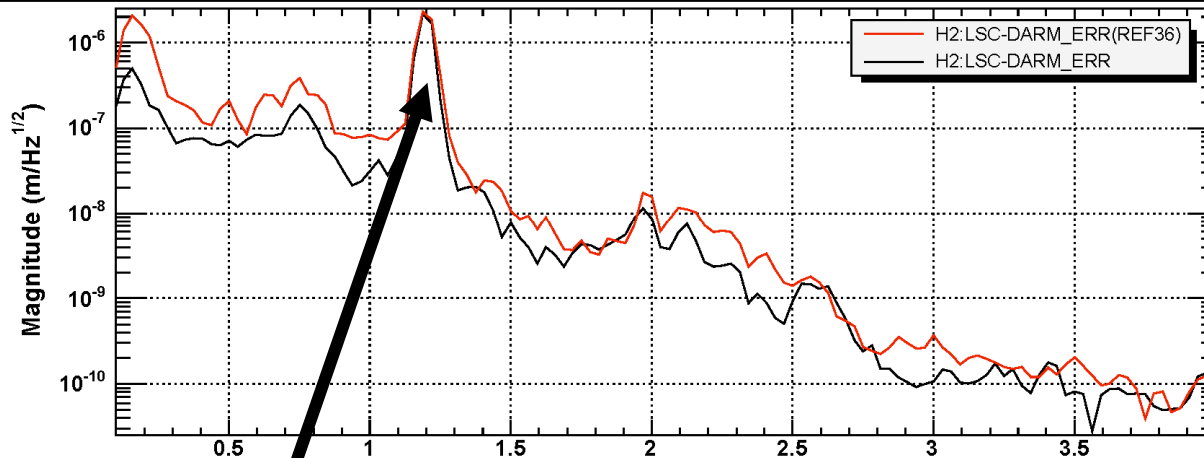
Blue peak is smaller than red in displacement and velocity but not in acceleration.



# Ground or isolation system motion **not** needed to produce up-conversion

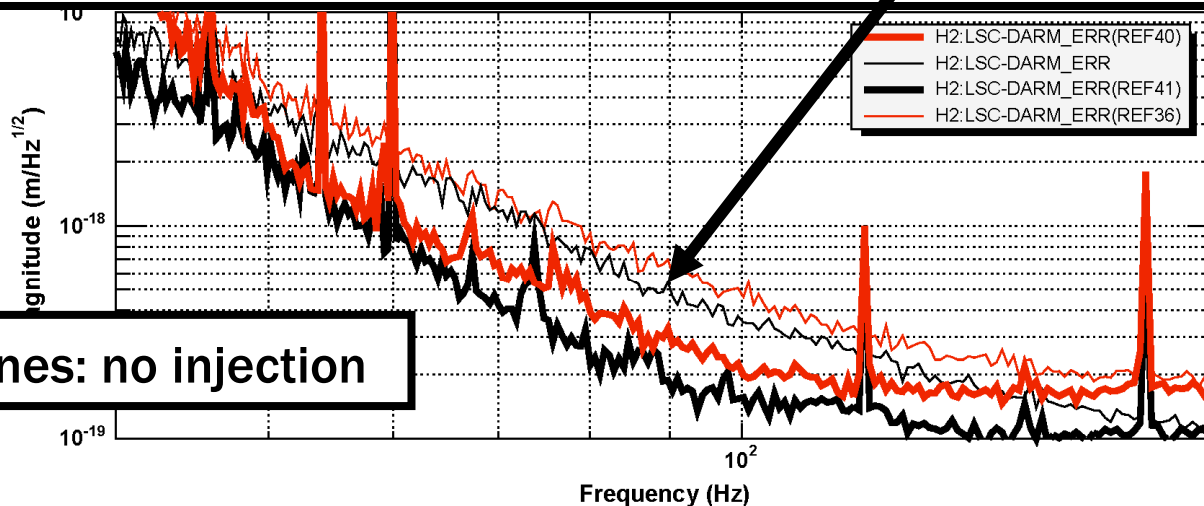
Black: ETMY coil injection; Red: ground shaking at ETMY

DARM  
low f



matched **ground** and coil injections produce similar upconversion

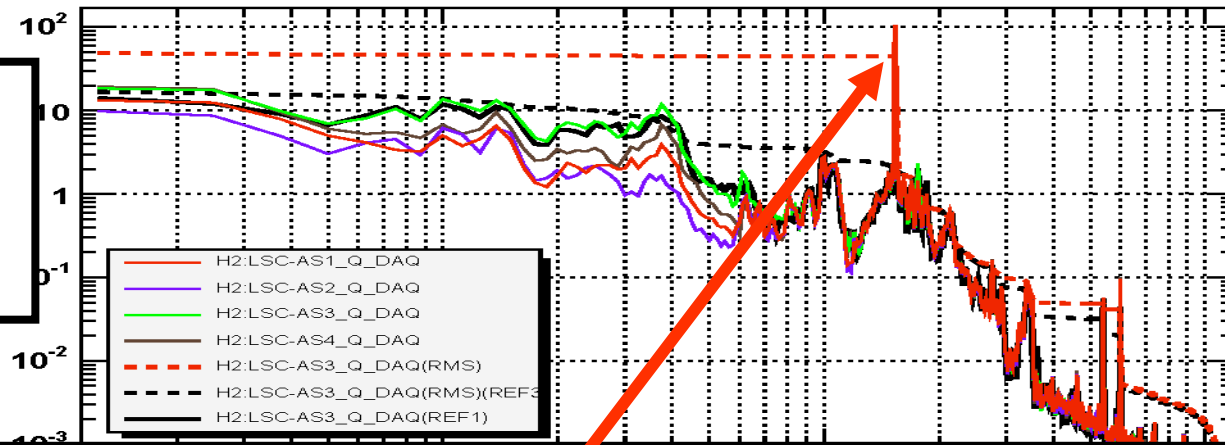
DARM  
high f



thick lines: no injection

# Up-conversion **not** from RF saturation

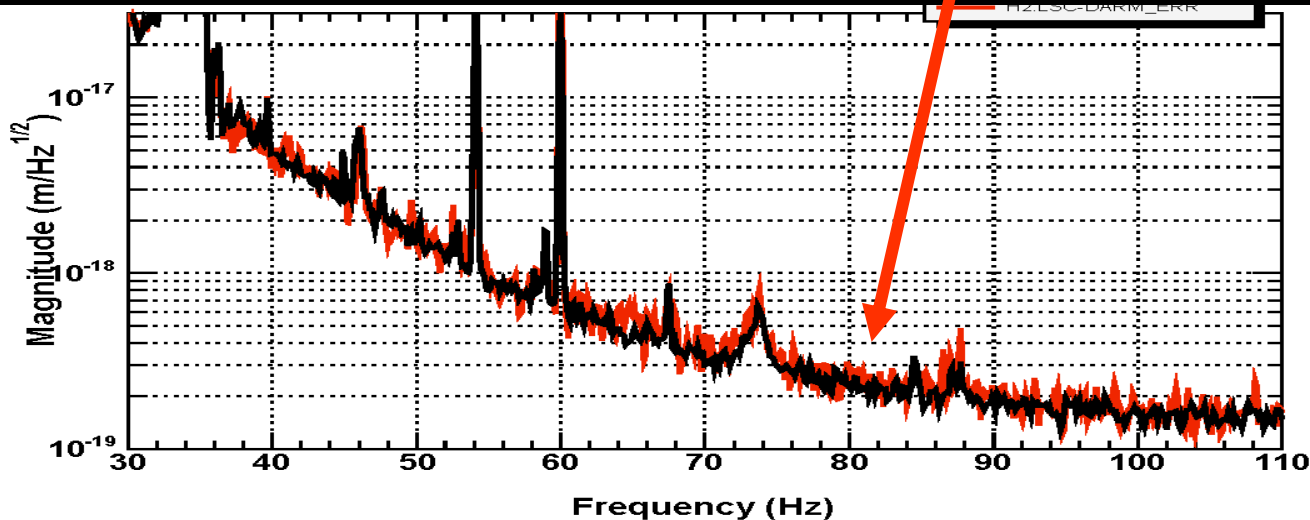
Power spectrum



uncalibrated  
DARM  
(proportional  
to RF current)

large DARM\_EXC injection does not produce upconversion

DARM



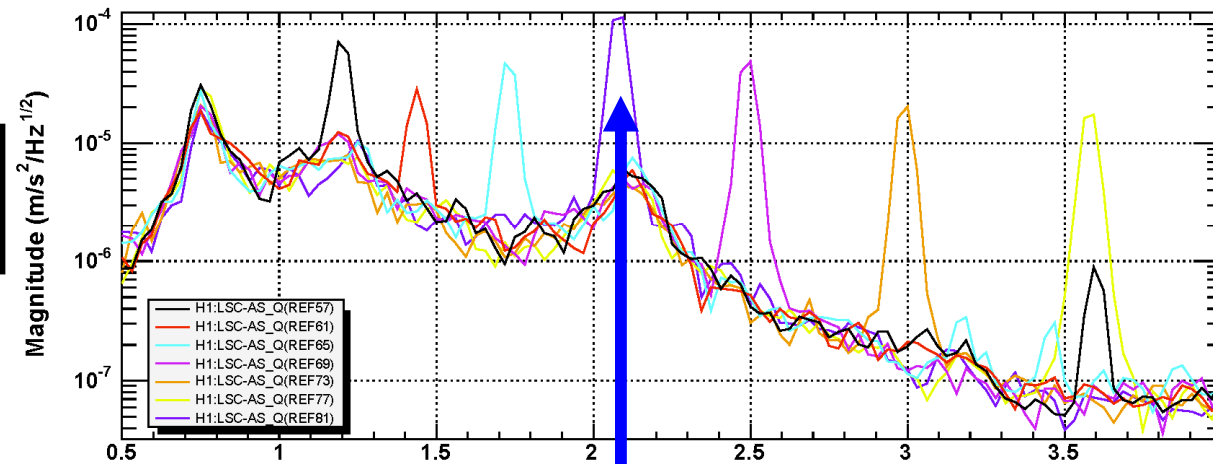
\*T0=20/02/2006 02:32:52

\*Avg=13

BW=0.1875

# Up-conversion best predicted by acceleration of optic

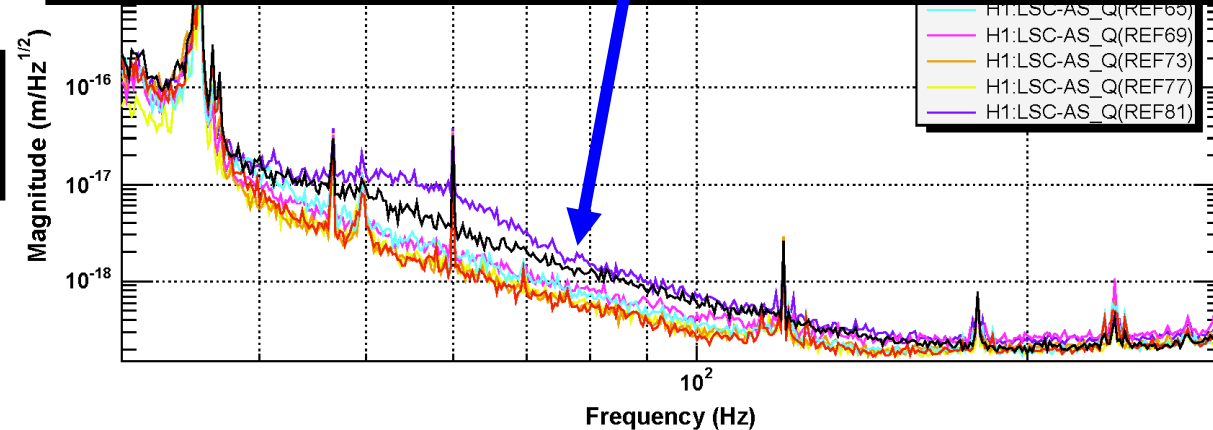
Power spectrum



DARM:  
acceleration

peak heights in acceleration plot (but not velocity or displacement) match up-conversion amplitude

DARM:  
displacement

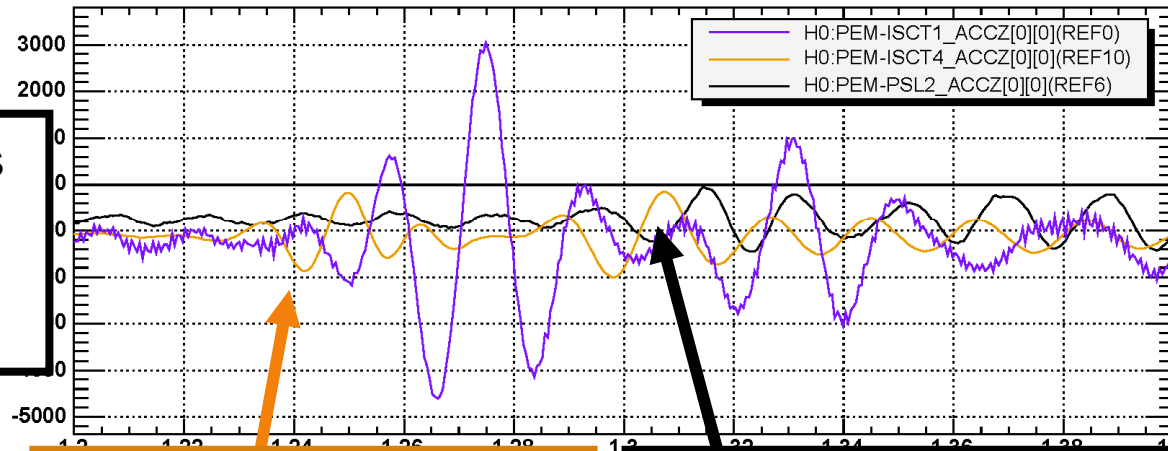


## Up-conversion summary

- *At low seismic amplitudes, not consistent with back-scattering*
- *Not suspension point mechanical up-conversion*
- *Ground or stack motion does not appear to be necessary (is produced by direct ETMY coil injection)*
- *Acceleration of test mass predicts up-conversion better than velocity or displacement.*
- *Not RF saturation*
- *Up-conversion in actuation system?*
- *Magnetic domain-flipping (Barkhausen) noise?*

# What produced coincident H1 H2 bursts during S4?

Accelerometer signals during an S4 H1-H2 coincident burst event

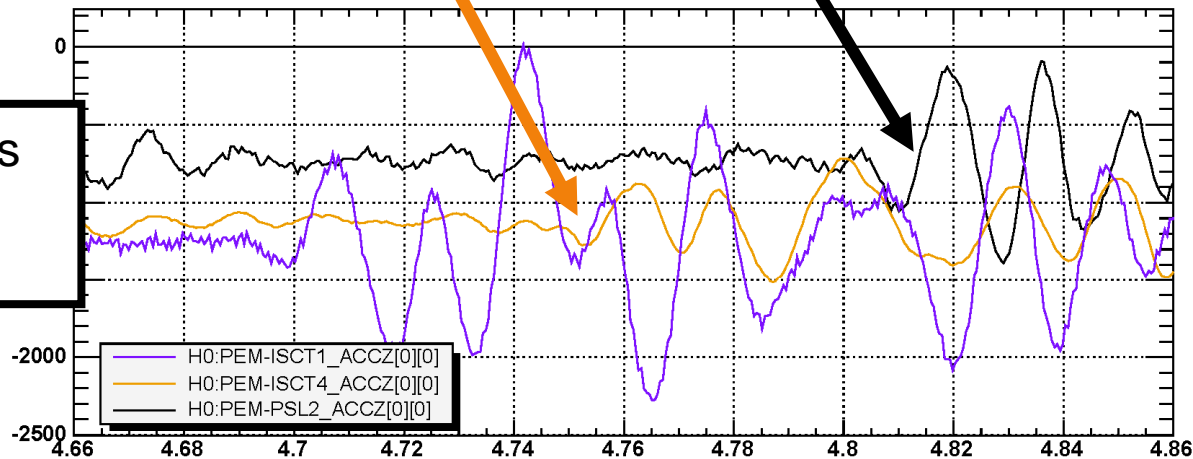


Accelerometers at time of S4 H1& H2 DARM burst

arrival not consistent

arrival not consistent

Accelerometers during jump in control room



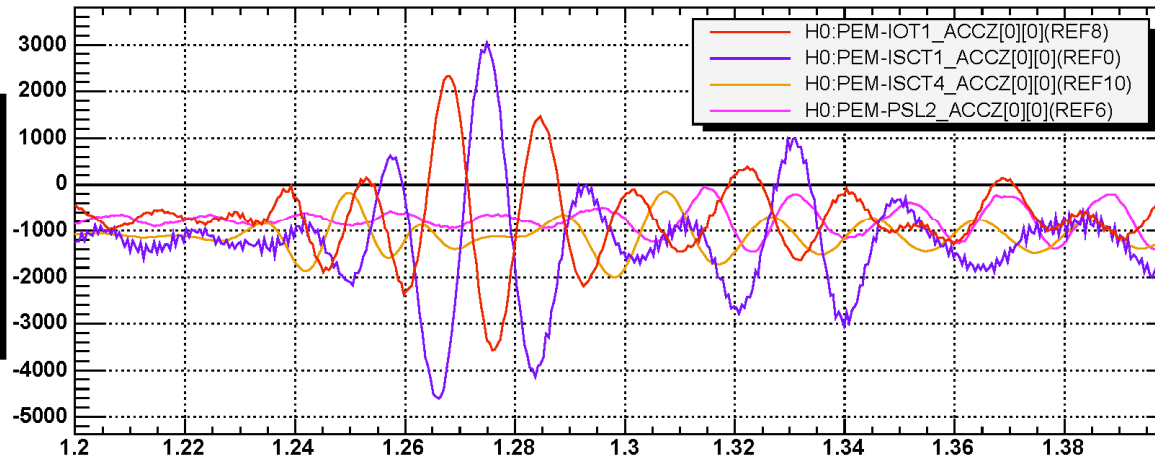
Time (s)

T0=11/10/2005 05:06:00

Avg=1

# Door slams and water bottle drop also not consistent (delay, amplitude, f), but fork lift set-down at shipping is.

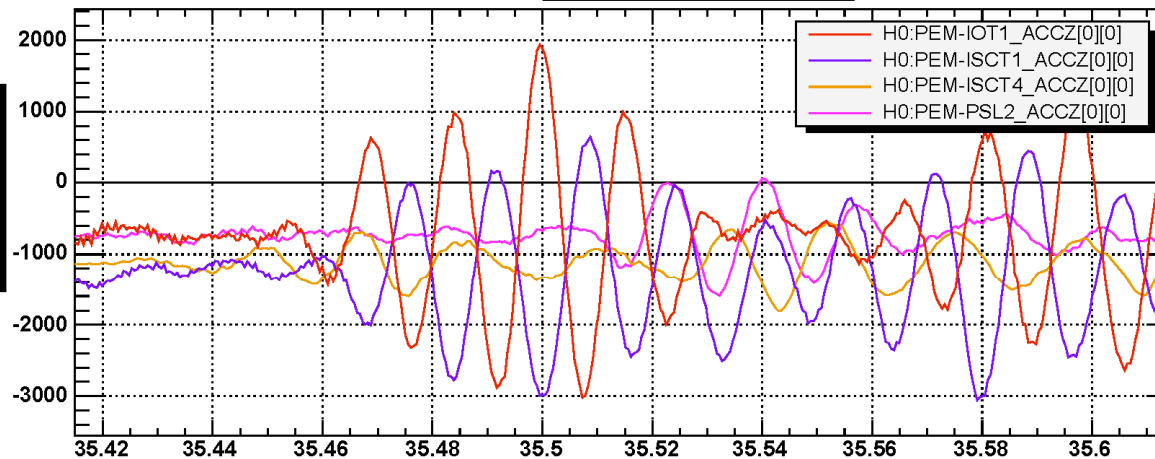
Accelerometer signals during an S4 H1-H2 coincident burst event



Accelerometers at time of S4 H1 & H2 DARM burst

Same signals for lowering of fork lift forks

Agreement



Accelerometers during set-down of fork lift forks

Time (s)

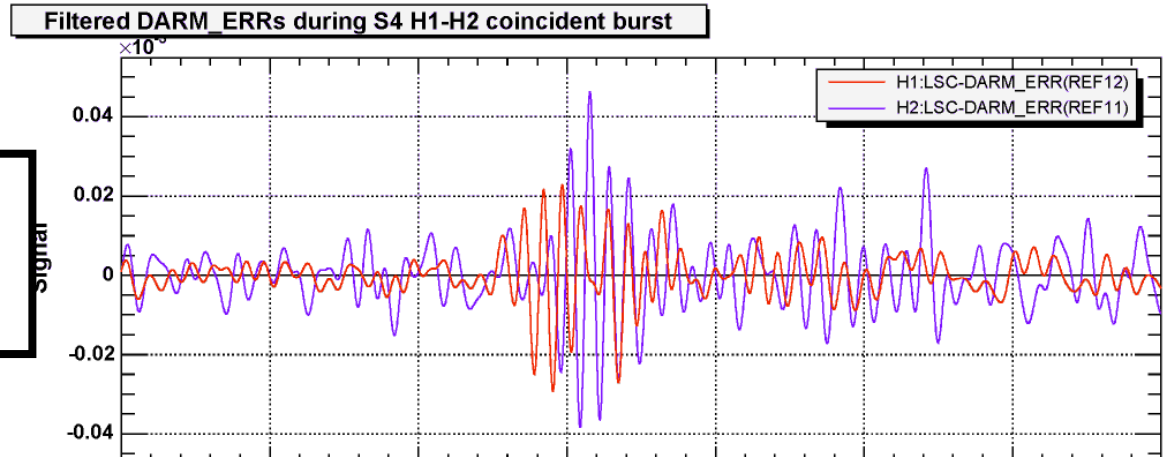
T0=16/10/2005 03:46:55

Avg=1

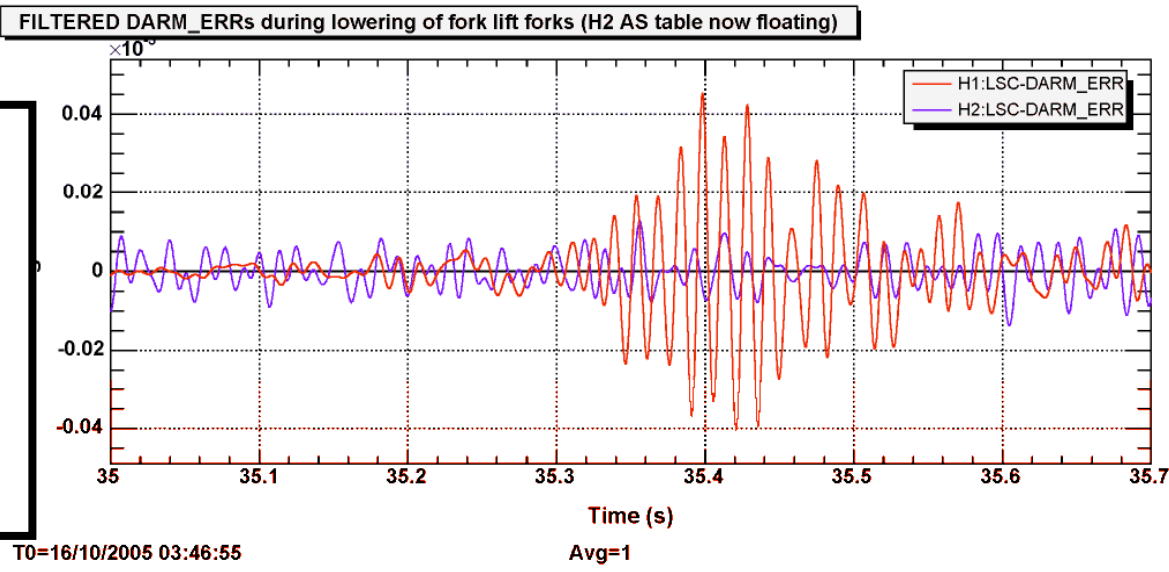


# “Floating” H2 dark port should reduce H1-H2 coincidences

H1 DARM, H2 DARM during S4 event



H1 DARM, H2 DARM during forklift event: with floating H2 dark port, very little signal is seen on H2



# S5 PEM Injections

- **LLO: Dec 10 2005 elog has burst injection times and transfer functions. Summary:**

- ACOUSTIC/SEISMIC - coupling lower than S4; no coupling found in electronics bays.
- MAGNETIC - coupling about the same as S4; we can not reduce DARM 60 Hz substantially without reducing 60 Hz ambient magnetic field; LVEA pulsed heating should be turned off.
- RF - external sources loud enough to occasionally show up in DARM - radio channels are important veto channels

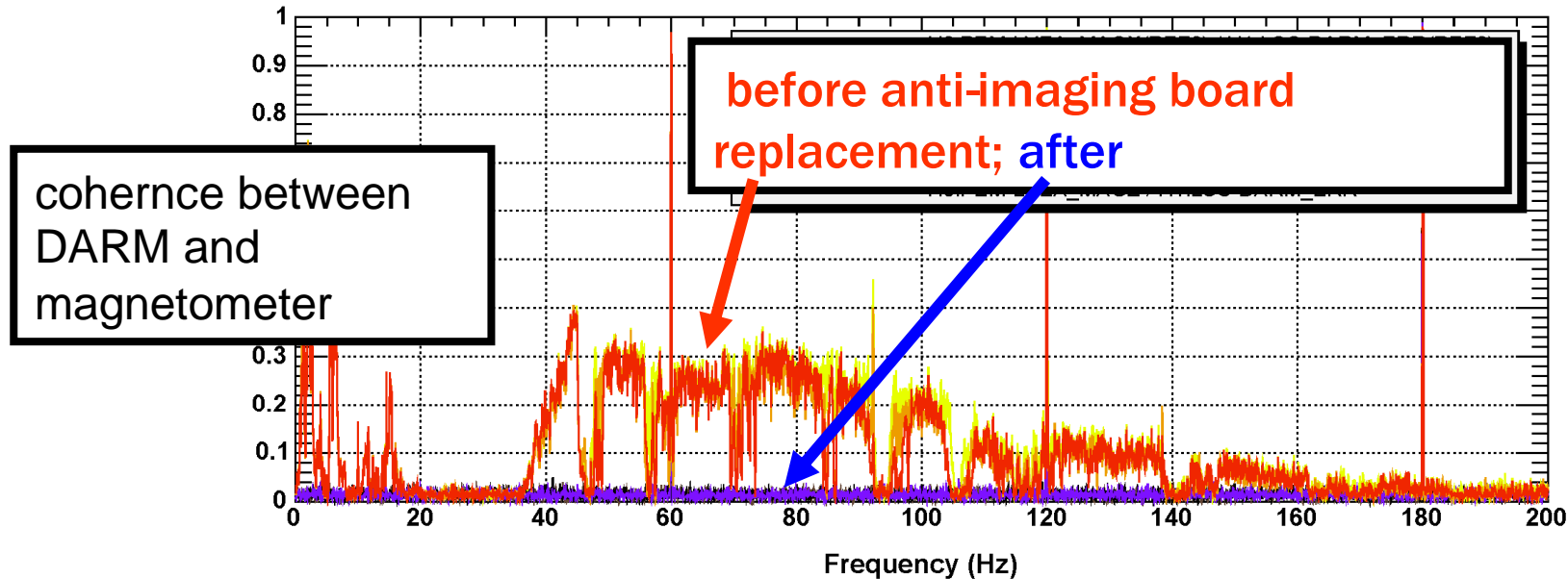
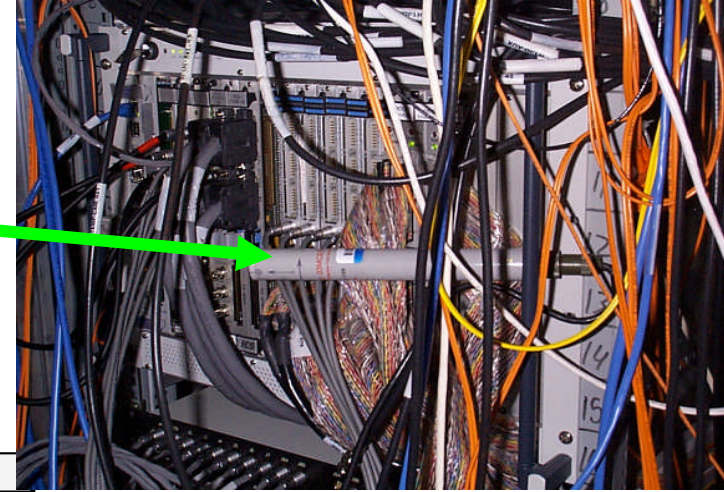
- **LHO: Jan 8 2006 elog has burst injection times, transfer functions. Summary:**

- ACOUSTIC/SEISMIC-coupling 5x lower than S4; possible backscattering problem from end-station transmitted ports.
- SEISMIC UPCONVERSION-same for all H1 and H2 out-stations, would be seen daily in H2 except for mystery noise.
- RF-about the same as S4: signal on RADIO\_LVEA about 100x SNR of DARM.
- MAGNETIC-about the same as S4: a substantial or dominant contributor to DARM 60 Hz, 3 Hz sidebands need fixing...



# Electronics racks magnetometer diagnostic

Magnetometer near electronics racks previously used to identify peaks in DARM from sources in electronics racks. During S5 break, broad band coherence between magnetometer and DARM led to discovery of bad board (which put ripple on power supply).



## Crab protection



Kyle Ryan improves the seismic isolation of the office area air handler, which has been running recently at 59.6 Hz

# LVEA HVAC experiments

CONFIGURATION	TOTAL LVEA FLOW (CFM)	SEIS_Z BAND (counts)	
		33-50 Hz	1-27 Hz
A) Original flow	40,000	15.7	52
B) 2 LVEA fans and labs at 50% flow	20,000	8.6	29
C) Full LVEA flow with 2 fans. Labs at 50%	40,000	12.3	40
D) Full LVEA flow with 3 fans. LABs at 50%	40,000	9.2	37
E) 75% LVEA flow with 3 fans. LABS at 50%	30,000	9.2	32
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F) 2 LVEA fans at 75% 2 LAB fans at 50%	30,000	9.5	34
G) 2 LVEA fans at 50% 2 LAB fans at 75%	20,000	9.8	35